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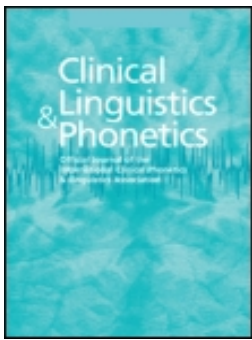
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## Sentence comprehension in Swahili–English bilingual agrammatic speakers

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### Abstract

For this study, sentence comprehension was tested in Swahili–English bilingual agrammatic speakers. The sentences were controlled for four factors: (1) order of the arguments (base vs. derived); (2) embedding (declarative vs. relative sentences); (3) overt use of the relative pronoun “who”; (4) language (English and Swahili). Two theories were tested: the Trace Deletion Hypothesis (TDH; [Grodzinsky, Y. (1995). A restrictive theory of agrammatic comprehension. *Brain and Language*, 50, 27–51]) that assumes a representational deficit in agrammatic aphasia and the Derived Order Problem Hypothesis (DOP-H; Bastiaanse & Van Zonneveld, 2005), which is a processing account. Both theories have the same predictions for sentences in derived order. The difference is that the TDH predicts chance level performance for sentences in which the arguments are not in base order, whereas the DOP-H predicts poorer performance when processing demands increase. The results show that word order influences performance, in that sentences in which the arguments are in derived order are harder to comprehend than sentences in which the arguments are in base order. However, there is a significant interaction with the factor “embedding”: sentences with an embedding are harder to comprehend than simple declaratives and this influence is larger in derived order sentences. There is no effect of language nor of the use of a relative pronoun. These results are correctly accounted for by the DOP-H.

**Keywords:** agrammatism; bilingualism; Swahili; base order; derived order; TDH and DOP-H

### Introduction

Individuals with agrammatic Broca’s aphasia are generally assumed not only to produce slow and effortful speech, with short phrases consisting of mainly content words, but also to have a relatively intact language comprehension ability. However, there is substantial empirical evidence to suggest that certain linguistically complex sentence types are difficult to comprehend for monolingual agrammatic speakers (cf. Bastiaanse & Edwards, 2004; Caramazza & Zurif, 1976; Grodzinsky, 2000). Particularly vulnerable are the semantically reversible sentences whose arguments are not in their base position, such as object clefts, passives, and object relative sentences. Several theories have been formulated to account for this phenomenon, some of which have contributed substantially

to our understanding of language comprehension in individuals with agrammatic Broca's aphasia. However, the focus has been almost exclusively on monolingual speakers, with hardly any attention given to comprehension patterns in bilinguals, especially to speakers of two morphologically different languages. The current study examines the comprehension patterns in pre-morbidly highly proficient bilingual speakers of Swahili and English, two languages that possess contrasting morphological and syntactic properties. We start by giving some background on relevant Swahili syntax and verb morphology. Next, we provide an overview of comprehension theories in agrammatic aphasia. This will be followed by a review of some previous studies on Swahili–English bilingual agrammatic aphasia. We conclude the introduction by providing the aims and predictions for the current study.

### *Swahili syntax and verb morphology*

*Syntax (word order).* According to Ashton (1982), Swahili, like many other Bantu languages, is a highly agglutinating and mostly prefixing language with a fairly fixed base word order (subject/agent–verb–object/theme: SVO), where the agent precedes the verb and the theme (see 1a and b). Although the second illustration (1b) is a subject relative clause, the agent and theme maintain the base order. We call these “base order sentences.” Sentences with derived order of the arguments, such as passives (subject/theme–verb–prepositional phrase/agent), object relatives (object/theme–subject/agent–verb) with and without complementizer are also possible. These we call “derived order sentences.” In derived order sentences, the arguments are no longer in their base positions as exemplified in (2a and b).

#### (1a) Base order, simple active (agent – theme)

Kijana	a-na-m-gonga	msichana
Boy	s/he-PRESENT-him/her-hit	girl

“The boy is hitting the girl”

#### (1b) Base order, subject relative (agent – theme)

Kijana	ambaye	a-na-m-gonga	msichana
Boy	who	s/he-PRESENT-him/her-hit	girl

“The boy who is hitting the girl”...

#### (2a) Derived order, passive (theme – agent)

Msichana	a-na-gong-wa	na	kijana
Girl	s/he-PRESENT-hit-PASSIVE	by	boy

“The girl is hit by the boy”...

#### (2b) Derived order, object relative + relative pronoun (theme – agent)

Msichana	ambaye	kijana	a-na-m-gonga
Girl	who	boy	s/he-PRESENT-him/her-hit

“The girl who the boy is hitting” ...

#### (2c) Derived order, object relative – relative pronoun (theme – agent)

Msichana	kijana	a-na-m-gonga
Girl	boy	s/he-PRESENT-him/her-hit

“The girl the boy is hitting”...

In a passive sentence (2a), the theme is in clause-initial position, and the agent is in postverbal position in the prepositional phrase. The final suffix of the verb complex also changes from “-a” to

passive marker “-wa.” As in English, the phrase “na” (by) is included only if the information that follows is important for clarity purposes to the reader or the listener. In an object relative sentence (2b), the theme is in initial position, the relative pronoun “ambaye” (who) preludes the embedded sentence. However, just like in English, the relative pronoun may be left out, as shown in (2c).

*Verb morphology.* The Swahili verb morphology is distinctly more complex than that of English, consisting of numerous affixes, both inflectional and derivational morphemes, attached to the verb root. These affixes (prefixes and suffixes) must occupy specific positions and they perform specific functions. The general position scheme of the affixes in relation to the verb root is shown in (3a). Some illustrations from Abuom, Obler, and Bastiaanse (2011) are given in (3b–d).

- (3a) Pre-prefix (Pp) + Subject prefix (Sp) + Tense marker (T) + Object prefix (Op)  
+ ROOT + derivation (d) + Suffix (s) + Post-suffix (Ps).
- (3b) A + li + m + gong + a  
Sp + T + Op + ROOT + d  
“S/he hit him/her”
- (3c) Ha + tu + ta + m + gong + a  
Pp + Sp + T + Op + ROOT + d  
“We will not hit him/her”
- (3d) Tu + na + gong + a + n + a  
Sp + T + ROOT + d + S + Ps  
“We are hitting each other”

As illustrated in (3b–d), the Swahili verb complex, unlike that of English, can function as a complete sentence. The verbal complex consists of: the subject prefix (subject–verb agreement), the tense marker (includes tense and aspect) and the verb root, which are generally obligatory in every grammatical Swahili sentences. However, the object prefix is generally not obligatory when the object of the sentence is overtly present. The subject and object prefixes must always agree in number with the subject and the object of the sentence, respectively.

### *Two theories on sentence comprehension in agrammatic Brocas’s aphasia*

Several linguistic theories have been proposed to account for the sentence comprehension deficit in monolingual agrammatic individuals.<sup>1</sup> We discuss two theories here that formed the basis of this study. The Trace Deletion Hypothesis (TDH) proposed by Grodzinsky (1984), which has undergone a series of revisions (Drai & Grodzinsky, 2006; Grodzinsky, 1986, 1995), finds its origin in Chomsky’s Universal Grammar (see, e.g. Chomsky, 1995). According to this theory, constituents can “move out” their original position, leaving behind a “trace.” The trace and the antecedent are, thus, linked as shown by co-indexation in (4a–c). The thematic roles are assigned to the original positions in the sentences by the verb and they are transferred to the “moved” constituent via the trace.

- (4a) The boy<sub>i</sub> is hit *i*by the girl.  
(4b) The boy<sub>i</sub> who<sub>i</sub> the girl is hitting *i* ...  
(4c) The boy<sub>i</sub> the girl is hitting *i* ...

According to Grodzinsky’s TDH, in individuals with agrammatic aphasia, the traces are deleted from the sentence representation due to damage to Broca’s area. As a result, the verb cannot assign a thematic role to the moved constituent. In order to interpret such sentences, the agrammatic individuals apply a non-syntactic “default strategy” and assign an agent role to the first NP (“the boy”) because usually the first NP is the agent. The second NP also gets an agent role, directly assigned by the verb. As a result, the aphasic individuals are faced with a representation consisting of two

agents (the boy and the girl) and they have to guess, leading to chance level performance. In subject relatives (“the boy who is hitting the girl...”), “the boy” is not assigned a thematic role either, because the NP has been moved from its original position and the trace is deleted. However, the default strategy assigns the agent role to this first NP and the verb assigns the theme role to the second NP, resulting in a correct interpretation of the sentence.

It is important to note that the TDH assumes that individuals with agrammatic aphasia suffer from a representational deficit. The sentence representations are damaged because the traces are lost. This means that they always apply the default strategy: they can never assign a thematic role to a moved argument. Therefore, their performance will be at chance for all sentences in which the order of the thematic roles is non-canonical (between 33 and 67% correct on a binary choice test) and above chance on sentences where the agent is in first position.

The Derived Order Problem Hypothesis (DOP-H) has a larger scope than the TDH and it is meant to describe the production and comprehension deficits in agrammatic aphasia. It is based on data from many languages (Dutch, English, Turkish, Italian; see, for example, Bastiaanse, Edwards, Maas, & Rispens, 2003; Bastiaanse & Thompson, 2003; Bastiaanse & Van Zonneveld, 2005, 2006; YarbayDuman, Aygen, Özgirgin, & Bastiaanse, 2007; YarbayDuman, Aygen, & Bastiaanse, 2008; YarbayDuman, Özgirgin, Altinok, & Bastiaanse, 2011). Contrary to the TDH, it does not assume a representational deficit, but a processing disorder, meaning that the sentence representations are intact, but linguistic operations cannot always be performed correctly. The more complex the operations are, the more difficult the processing will be. The underlying idea is that each language has a base order in which constituents that naturally belong together are adjacent. In English, for example, the base word order is Subject–Verb–Object (SVO), whereas in Dutch and German it is Subject–Object–Verb (SOV). All other word orders are derived. Notice that the DOP-H is relatively theory free: although embedded in the Chomskyan tradition, there is no strong idea about movement, merging, or traces. The DOP-H assumes that in order to produce or comprehend a derived word order sentence, extra grammatical operations have to be performed and this is exactly what is difficult for agrammatic speakers. For production, this means that predominantly simple, base order sentences will be produced and for comprehension that semantically reversible sentences with derived order of the arguments will be poorly understood. The DOP-H assumes, just like the TDH, that agrammatic individuals, when faced with a sentence with derived word order, may resort to a default strategy that the first NP is the agent. The main difference between the TDH and the DOP-H is that the DOP-H does not assume that the agrammatic individuals can never parse (or produce) a sentence with derived order of the arguments correctly; they cannot do this correctly all the time and the more processing is required, the more errors they will make. With regard to performance level, this implies that the TDH predicts chance level performance for all sentence types with derived order of the arguments. The DOP-H predicts poorer performance on sentences in which the order of the arguments is derived and that when further complexity is added, performance will further decrease.

In a study similar to the current one, YarbayDuman et al. (2011) studied agrammatic sentence comprehension in Turkish. Turkish has a relatively free word order and a complex case system. Interestingly, some derived word order sentence types require a special case assignment system. For example, in object relatives, the subject has genitive case and the object has nominative case. YarbayDuman et al. (2011) found an interaction effect of word order and case: when case was not according to its default distribution (subject = nominative, object = accusative), performance diminished. This is compatible with a processing account like the DOP-H: comprehension of sentences with derived order of the arguments is impaired due to a processing disorder; adding complexity to these derived order sentences further diminishes performance.

In sum, both the TDH and DOP-H predict that agrammatic speakers have difficulty understanding sentences in derived word order. While TDH predicts above chance level performance for base order sentences and chance level performance for derived order sentences, the DOP-H predicts better

performance for base order sentences than for derived order sentences and further decline of performance when linguistic complexity is added to the sentence.

There are two other accounts that could be relevant to our study. The first has to do with Working Memory (WM). It has been argued that comprehension of derived order sentences can be impaired because of an overload on the aphasic individuals' WM capacity, which is generally assumed to be impaired (Burgio & Basso, 1997; Ivanova & Hallowell, 2012; King & Just, 1991; Miyake, Carpenter, & Just, 1994). The question is, of course, how WM impairments may affect comprehension of some sentence types but not of others, that is, what units and/or processes influence the WM operations? It has been argued that the number of words may play a role, or rather the number of lexical items. The number of lexical items is the same in our sentences, but the number of words varies. Interestingly, the sentences are consistently shorter in Swahili than in English. Thus, if one accepts that more words in a sentence negatively affect agrammatic performance, then the Swahili–English bilingual agrammatic individuals should perform worse in English than in Swahili. An alternative WM account argues that it is the distance between the filler and the gap which is critical, that is, the more words between the filler (the argument that has been extracted from its base position) and the gap (the resulting “empty” base position), the harder it is to process the sentences, because the time that the filler should be kept in (the impaired) WM is longer (e.g. Frazier & Friederici, 1991; but see Friedmann & Gvion, 2003; Gvion & Friedmann, in press for counter evidence). For checking this, a study on bilingual aphasia is particularly interesting, because, again, this distance is consistently shorter in all Swahili-derived word order sentences than in the English counterparts. However, this account makes predictions for within language comparison as well. For example, for English, performance should be better on the object relatives without complementizer, since the distance is one word shorter. Another suggestion with respect to WM is that in long sentences, the middle part is lost due to the WM deficit. In (5a–c), the resulting structures are given.

- (5a) passive  
 the man is rescued by the woman → the man ... the woman
- (5b) subject relative  
 (...) the woman who rescues the man → the woman ... the man
- (5c) object relative  
 (...) the man (who) the woman rescues → the man ... rescues

If one assumes something like a default strategy that makes the agrammatic individual assign the agent role to the first NP, then comprehension of passives and object relatives will be impaired on a binary choice test if the distractor depicts the same action as the target picture, but with the thematic roles reversed. They will perform relatively well on the subject relatives. However, when a test with four pictures is used, in which the two extra alternatives depict a different action with the same participants (one with the same agent – theme relation as in the target sentence and one with the roles reversed), then the agrammatic individuals will point to one of the lexical distractors when hearing a subject relative or a passive, because the verb is wiped from WM. Although not the major focus of the current paper, we will address this WM account in the Discussion Section.

The data from Swahili–English bilingual agrammatic speakers provide a valuable site for testing the prediction of these theories, as these languages differ in their morpho-syntax: while English has relatively simple morphology, Swahili has a markedly agglutinative morphology with an extra passive marker on the verb. The question for the present study is whether the passive marker on the verb influences performance in Swahili.

#### *Previous studies on Swahili–English bilingual agrammatic aphasia*

For the present study, the term “bilingual” has been used to include multilingual persons who speak two or more languages or dialects in their everyday lives (Grosjean, 1994). It has been reported in



several studies on bilingual aphasia that most individuals suffer from the same type of aphasia in all their languages acquired before an aphasia-producing incident; and the recovery pattern is often parallel (Abutalebi, Cappa, & Perani, 2005; Fabbro, 1999, 2001; Miozzo, Costa, Hernández, & Rapp, 2010; Paradis, 2001); however, non-parallel recovery patterns have also been reported (Albert & Obler, 1978; Fabbro, 1999). The differential recovery patterns are argued to stem from differences in the age of acquisition, frequency of use, or proficiency level between the languages acquired before an aphasia producing incident. The aphasic participants in the present study are all balanced and proficient bilinguals, who acquired all their three languages (native language, Swahili and English) early in life. It is generally assumed that such bilinguals have shared language processing brain regions (e.g. Abutalebi et al., 2005; Miozzo et al., 2010). One of the consequences of shared language processing regions has been reflected in the limited number of studies that we have conducted on Swahili–English agrammatic speakers. In our first study, Abuom and Bastiaanse (2012), we analyzed the production of verb forms for reference to the past and to the present in the spontaneous speech of early balanced agrammatic individuals. The proportion of verb forms referring to the present was normal in their spontaneous speech, but the proportion of verb forms referring to the past was significantly lower than normal. The pattern of performance in both languages was parallel. In our second study (Abuom & Bastiaanse, 2013), agrammatic speakers were tested on production and comprehension of verb forms referring to the past, present and future, using both sentence completion and sentence–picture matching tasks. Their performance showed a selective deficit of reference to the past on both comprehension and production tasks. Again, the pattern of performance was similar in both languages in spite of the morphological differences.

What these studies show is that Swahili–English agrammatic speakers have a selective difficulty producing and comprehending sentences in base word order referring to a past time frame, but not to a present time frame. How they produce or comprehend sentences in derived word order is not known yet. The difficulty with base order sentences in the past time frame, which has been found in several other languages in monolingual agrammatic individuals (Bastiaanse, 2013; Bastiaanse et al., 2011), is reflected similarly in both languages of Swahili–English bilingual speakers. It is, however, unclear whether the difficulty with comprehension of sentences in derived word order, found in monolingual studies of other several languages (Dutch, English, Turkish, and German), is reflected in a similar way in Swahili–English bilingual agrammatic individuals. Furthermore, it is interesting to find out if the difficulty with derived order sentences affects both languages of bilinguals in a similar way, quantitatively and qualitatively.

### *The predictions for the current study*

Based on the studies of spontaneous speech and time reference in bilingual Swahili–English agrammatic speakers, we expect similar performance across the two languages regardless of the morphological differences in their verb inflection systems.

With respect to the empirical validity of the two theories (TDH and DOP-H) in Swahili–English bilingual agrammatic individuals, the following is predicted. The TDH (Drai & Grodzinsky, 2006; Grodzinsky, 1986, 1995) predicts (a) above chance level performance for sentences in which the order of the arguments is canonical: active and subject relative sentences in both languages; (b) chance level performance for sentences in which the theme precedes the agent: passive, object relative sentences with and without relative pronoun. The DOP-H (Bastiaanse & Van Zonneveld, 2005) predicts (a) good performance for sentences with the arguments in base order: active and subject relative sentences; (b) poor performance on sentences with derived order of the arguments: passive, object relatives with and without relative pronoun. Furthermore, the DOP-H assumes that added linguistic complexity will lead to additional problems understanding sentences with derived order of the arguments. It is, thus, expected that the extra operation needed for the



embedding will influence parsing. In other words, the DOP-H predicts an interaction effect of derived order and embedding, so that it predicts: simple active < subject relative < passive < object relative  $\pm$  relative pronoun.

In Swahili, the finite verb is morphologically more complex than in English, and the study of YarbayDuman et al. (2011) showed that case morphology interacts with derived order. However, case is a crucial factor for sentence comprehension in Turkish and depends on the sentence type. This is not so for Swahili verb morphology for most sentence types. However, it may be that the passive marker on the verb in Swahili facilitates or complicates performance. This can be accounted for by the DOP-H but not by the TDH.

A WM account predicts poorer performance on longer sentences or longer filler – gap distances. It predicts typical performance: role reversals in passives and lexical (+role reversals) in object clefts.

A final point that should be mentioned is that it is not *a priori* clear whether we should expect similar impairments in the two languages of the bilingual agrammatic individuals. According to Paradis (1988) and Fabbro (2001), a central underlying deficit in bilingual individuals with agrammatic aphasia may cause different surface manifestations in the languages that differ in their grammatical morphology. Taking into account the results of our previous studies in a Swahili–English bilingual agrammatic population, we expect to find similar patterns in both languages, although the extra verb morpheme in Swahili passives may lead to poorer performance in Swahili than English on this sentence type.

## Methods

### *Participants*

There were 11 non-fluent aphasic/agrammatic and 11 non-brain-damaged (NBD) participants in the study.<sup>2</sup> Each participant spoke a Bantu or Nilotic or Indo-Aryan language natively, but all spoke English and Swahili as second languages, learned from 4 years old at school. The NBDs were, as a group, matched on age, native language, and education (a minimum of high school diploma: over 12 years of uninterrupted exposure to English and Swahili) with the agrammatic individuals. The agrammatic individuals were pre-morbidly highly proficient in the two second languages. All participants were right-handed and without a history of psychiatric or developmental speech or language disorders or any other neurological conditions. The aphasic individuals were assessed and diagnosed as suffering from aphasia by both the neurologist and speech therapist at the speech therapy department of the Aga Khan University hospital. The speech therapist confirmed that all the aphasic participants produced speech that was clinically judged as non-fluent and “telegraphic” (slow, effortful with short and simple utterances consisting of mainly content words)<sup>3</sup>. Their comprehension of single words in both languages was relatively good, based on their performance on an adapted version of the subtask for auditory comprehension of single words (nouns, verbs, colors, shapes, letters, numbers) from the *Boston Diagnostic Aphasia Examination* (BDAE: Goodglass & Kaplan, 1972). A few pictures of this task were substituted, because some items are unknown in Kenya and, hence, no Swahili word was available (for example, the hammock was changed to a swing). The level of comprehension of sentences in both languages was also found to be comparable based on their performance on a syntactic comprehension test ( $t(10) = 0.48$ ,  $p = 0.64$ ), a sub-test of *Bilingual Aphasia Test* (BAT: Paradis & Mwansasu, 1990). The demographic details of the participants and their scores on the BDAE subtest for auditory word comprehension and on the BAT subtest for syntactic comprehension are shown in Table 1. Considering their agrammatic output in both languages and their relatively good comprehension, it is assumed that they suffer from classical Broca’s aphasia.

Table 1. Demographic details of the agrammatic individuals and their scores (% correct) on the test for auditory comprehension of words (on an adapted version of the BDAE test) and on the subtest of Bilingual Aphasia Test (BAT) in Swahili and English.

	Age (years)	Gender	Handedness	Education (years)	Years post-stroke/ head trauma	Native language	Swahili BDAE- subtest scores	English BDEA- subtest scores	Swahili BAT- subtest scores	English BAT- subtest scores
EA	42	M	R	16	17	Nilotic	100	99	59	60
JN	50	F	R	13	10	Bantu	100	100	74	57
SS	30	F	R	12	17	Indo-Aryan	100	99	64	71
PN	36	F	R	14	1	Bantu	100	100	60	70
MM	47	F	R	16	10	Nilotic	100	100	83	83
JA	46	M	R	16	1	Bantu	100	100	67	63
MW	50	F	R	16	1.5	Bantu	98.6	100	66	67
HJ	45	F	R	14	10	Nilotic	100	100	64	64
VK	25	F	R	16	2	Bantu	100	98.6	86	84
HS	64	M	R	16	1	Indo-Aryan	99	98.6	64	60
BM	53	F	R	12	0.5	Bantu	100	100	66	63
Mean	44.36			14.64	6.45		99.8	99.6	68.5	67.5

Table 2. Examples of target sentences in the sentence–picture matching task.

Condition	Sentence types	Target sentence in English	Target sentence in Swahili
Base order	Active	The man is rescuing the woman	Mwanamme anamwokoa mwanamke
	Subject relative	Point to the man who is rescuing the woman	Nionyeshe mwanamme ambaye anamwokoa mwanamke
Derived order	Passive	The woman is rescued by the man	Mwanamke anaokolewa na mwanamme
	Object relative + relative pronoun	Point to the woman who the man is rescuing	Nionyeshe mwanamke ambaye mwanamme anamwokoa
	Object relative – relative pronoun	Point to the woman the man is rescuing	Nionyeshe mwanamke mwanamme anamwokoa

### Materials and procedure

An adaptation of the sub-test of the Verb and Sentence Test (Bastiaanse, Edwards, & Rispen, 2002; Bastiaanse et al., 2003) for sentence comprehension to Swahili and English was used to test whether word order, embedding and verb complexity influence comprehension differently in the two languages of bilingual agrammatic individuals. The task in each language included 200 semantically reversible sentences (all in the present time frame) distributed equally into five sentence types: 40 active sentences; 40 passive sentences; 40 subject relative sentences; 40 object relative sentences with and 40 object relative sentences without relative pronoun. In Table 2, example sentences for each condition are given. All sentences had a transitive action verb with NPs in singular form. There were 40 sets of pictures, with each page consisting of a set of four different pictures.

The tasks involved auditory sentence–picture matching. The participant was shown a set of four pictures on one page and was asked to look at them all. The examiner read a sentence aloud and



Figure 1. An example of a set of pictures used in sentence–picture matching task taken from the VAST (Bastiaanse et al., 2002).

asked the participant to point to the picture matching the sentence (see 5 and Figure 1). One picture matched the sentence and the three other pictures were distractors to help determine error types: reversed role distractor, lexical distractor, and reversed role + lexical distractor.

(5) Experimenter:

Mwanamme    a-na-m-wokoa                      mwanamke  
Man            he/she-Present-him/her-rescue        woman  
“The man is rescuing the woman”

The two languages were tested separately on two different days with an interval of 2 weeks for each of the agrammatic individuals. The order of the tests in each language was varied for each participant: either English first, followed by Swahili or vice versa. To ensure the participants understood the task before starting the test, each session began with 10 practice items during which corrections were allowed and feedback given. No further feedback was given once the test began. Each session lasted 2 h, with a break for the agrammatic speakers. All the sessions were held in a speech therapy room at the Aga Khan University Hospital in Nairobi, Kenya.

Results

The NBDs made no errors on either test. The results of the agrammatic speakers are shown in Tables 3 and 4.

In order to test the TDH, it was compared whether or not the agrammatic individuals performed at chance level. Since virtually all errors (>95%) were simple role reversals, chance level was set on 50%, ±16.7% correct (33.3–66.7%). It can be seen from the tables that the TDH correctly predicts the performance on most sentence types but not on the passives in English, on which the agrammatic individuals perform slightly above chance level. However, what the TDH ignores is the different level of performance between the passives and the object relatives. An ANOVA was applied, to test for interaction effects between derived word order and embedding, as predicted by the DOP-H.

We performed a repeated measures analysis of variance to investigate the main effects of language (English and Swahili), word order (base and derived) and embedding (declaratives and relatives) on agrammatic performance. There was no statistically significant effect for language ( $F(1,10) = 2.882, p = 0.120$ : Swahili and English were similarly affected. There was a statistically

Table 3. The percentages correct of the agrammatic individuals on the Swahili test.

	Base order		Derived order		
	Actives	Subject relatives	Passives	Object relatives +	Object relatives+
EA	100	95	63	40	60
JN	100	95	68	60	53
SS	100	100	85	55	33
PN	100	93	60	40	40
MM	100	100	80	68	68
JA	100	100	63	58	53
MW	98	98	55	58	63
HJ	100	100	78	73	70
VK	100	100	80	63	58
HS	100	100	68	53	50
BM	100	100	63	53	50
Mean	99.8	98.3	69.4	56.5	54.4

Table 4. The percentages correct of the agrammatic individuals on the English test.

	Base order		Derived order		
	Actives	Subject relatives	Passives	Object relatives +	Object relatives+
EA	95	95	60	43	38
JN	100	95	53	43	50
SS	100	95	83	60	53
PN	100	95	65	48	38
MM	100	100	78	63	70
JA	100	98	55	48	35
MW	100	100	80	55	65
HJ	100	100	65	75	80
VK	100	100	50	40	53
HS	100	98	63	45	40
BM	98	95	53	48	45
Mean	99.4	97.4	64.1	51.6	51.5

significant main effect for word order:  $F(1,10) = 321.723, p = 0.000$ ). Furthermore, there was a statistically significant main effect for embedding: ( $F(1,10) = 23.056, p = 0.001$ ). There were no interaction effects for language  $\times$  word order ( $F(1,10) = 1.996, p = 0.188$ ) nor for language  $\times$  embedding ( $F(1,10) = 0.078, p = 0.786$ ). However, there was a significant interaction effect for word order  $\times$  embedding ( $F(1,10) = 19.207, p = 0.001$ ). The interaction effect of word order  $\times$  embedding is graphically shown in Figure 2.

*T*-tests were performed to further explore the significant effects. Both in Swahili and in English, there was a significant effect of argument order: performance on sentences with derived order was worse than on sentences with base order of the arguments (Swahili:  $t(10) = 17.86, p < 0.0001$ ; English:  $t(10) = 14.26, p < 0.0001$ ). Performance on embedded sentences (subject relatives and both object relatives) was worse than on the declarative sentences (actives and passives) in both languages (Swahili:  $t(10) = 7.054, p = 0.0002$ ; English:  $t(10) = 6.982; p = 0.0002$ ).

Although there was no effect for language, we separately analyzed whether the verb morphology interacts with comprehension. In Swahili, the passive marker is part of the finite verb, whereas in English it is a preposition. This morphological difference does not influence performance ( $t(10) = 1.288, p = 0.228$ ).

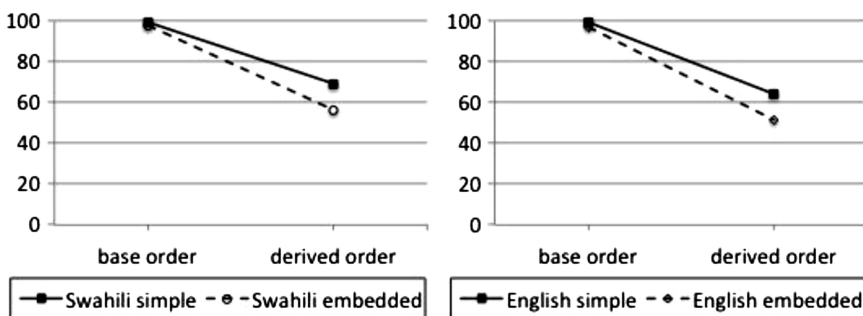
Figure 2. Illustration of the interaction effects for order  $\times$  embedding in Swahili and English.

Table 5. Distribution of error types (raw scores) of agrammatic individuals in Swahili and English tasks.

	Swahili			English		
	Role reversal	Lexical	Other	Role reversal	Lexical	Other
EA	50	7	0	64	4	0
JN	45	5	0	63	0	1
SS	51	0	0	40	3	1
PN	63	3	1	61	1	0
MM	33	1	0	36	0	0
JA	51	0	0	64	2	0
MW	50	2	0	54	1	1
HJ	32	0	0	32	0	0
VK	39	1	0	63	0	0
HS	51	1	0	59	3	0
BM	52	2	0	62	3	0
Mean	47.0	2.0	0.1	54.4	1.5	0.3

### *Error analysis*

The distribution of error types of the agrammatic speakers is presented in Table 5.

The agrammatic speakers pointed to each of the distracters, but not to the same extent. Role reversal errors were the most prevalent in both Swahili (95.7%) and English (96.8%). When agrammatic speakers heard sentences in derived order condition (passive, object relatives with and without relative pronoun), they most often pointed at the distracters in which the roles were reversed. A few lexical errors were also noted in Swahili (4.1%) and in English (2.7%) and a few errors that involved a combination of both role reversal and lexical errors in Swahili (0.2%) and in English (0.5%).

In sum, the agrammatic individuals performed more poorly on sentences in derived order condition than on those in base order condition and performance diminished when another complex grammatical operation has to be performed (embedding), as shown by the interaction effect. They make predominantly role reversal errors in both languages when they fail to understand sentences in derived order condition.

### *Swahili and English compared*

Although the factor “language” did not influence the performance, we looked at the correlation between the scores on the two languages, to see whether the agrammatic individuals are similarly affected in both languages. This is clearly the case: there is a strong and significant correlation between their scores in both languages:  $R = 0.92$ ,  $p < 0.0001$ .

## **Discussion**

The present study examined the comprehension of sentences with base and derived order of the arguments with and without embedding by bilingual agrammatic individuals. The results show that sentences in the derived order condition are more difficult to comprehend than those in base order and that there is an interaction effect for embedding. A similar pattern of performance is reflected in both languages, Swahili and English, irrespective of their morphological differences. This implies that the morphological differences in the verb inflection system of the two languages do not play a role in comprehending the sentences. We discuss these findings in relation to the theories of sentence comprehension in agrammatism mentioned in the Introduction Section.

*The problems with derived order*

Based on Grodzinsky and colleague's (1995, 2006) TDH, the following predictions were made for the current study: (a) above chance level performance for sentences in base order condition, actives and subject relative clauses, in both languages; (b) chance level performance for sentences in derived order condition, passives and object relatives with and without relative pronouns. Although our test had four pictures, only one of the distractors was purely related to word order and this was the picture chosen in the large majority of the errors. We, therefore, assumed that chance level was  $50 \pm 16.67\%$ . In both Swahili and English, the agrammatic individuals show good comprehension of both active and subject relative sentences with scores ranging from 93% to 100%. On the object relatives with and without relative pronoun, the scores are at chance level. So far, the scores are in line with the TDH. On passives in Swahili, however, the agrammatic individuals score above chance, which is incompatible with the TDH. The difference with chance level is not very large (69.4%), this alone is not a reason to reject the TDH, because there is overwhelming evidence that agrammatic individuals show around chance level performance on sentences in which the arguments are not in canonical order (see Grodzinsky, Piñango, Zurif, & Drai, 1999). However, what the TDH does not predict is the interaction effect between derived order of the arguments and embedding.

The DOP-H is a processing account that assumes worse performance when the syntactic operations become more complex, but it does not necessarily predict performance at chance level. The specific predictions were that sentences with derived order of the arguments are harder to understand and that embedding will further diminish performance, or, in terms of statistics, that there is an interaction effect of word order and embedding. This is exactly what has been found and this effect is largest in the derived order sentences. That does not mean that sentences with embeddings in which the arguments are in base order are processed faultlessly. It may very well be the case that these sentences are also harder to process, but that application of a default strategy results in almost perfect performance. On the basis of the current data, we cannot exclude this possibility (but see Friedmann, 2008, who showed that agrammatic individuals have problems understanding embedded sentences without traces).

*A working memory deficit?*

Depending on how one would like to measure a WM deficit, different predictions were considered in the Introduction, all of which are falsified by the data of the current study. The short Swahili sentences are comprehended equally well/poor as those in English in all conditions. Filler–gap distance does not play a role either: the object relatives with and without complementizer are understood equally well. A WM theory that assumes that the beginning and end of the sentence are retained in memory, whereas the middle part is wiped can account for the poor performance on the object relatives, but not on the passives. If in the latter structure the middle part of the sentence, the verb, is not available, lexical distractor pictures will be chosen, particularly those with role reversal, since the first NP will be interpreted as the agent. However, on the whole test by all agrammatic individuals, only four of these errors are made, one in Swahili and three in English. Also, lexical errors are expected for the subject relatives that have the verb in the middle, although without role reversals, because the first NP is the agent. In English in 1% and in Swahili in 0.5% of the items, such a distractor picture was chosen. Therefore, we do not think that a WM deficit can account for the data of the current study.

*The effect of the morphological difference between Swahili and English*

In Swahili, the finite verb is very complex, encapsulating information about the subject, the object, negation, time reference and, in passives, the finite verb contains the passive marker. However, the



language in which the agrammatic individuals were tested did not influence their behavior, implying that the verb complexity does not contribute to their level of performance. This is interesting, because another factor, embedding, does affect their comprehension. Hence, the data suggest that performance, on a test where word order is a crucial clue to understand the sentence, is influenced by structural complexity and not by morphological complexity. That does not mean that their comprehension is not affected by verb morphology at all. From two previous studies (Abuom & Bastiaanse, 2012, 2013), we know that Swahili–English bilingual agrammatic individuals have problems with verb inflection when it is used for reference to the past (“he pushed” is more difficult than “he is pushing” and “he will push”) in comprehension and in production in both languages. However, on the current experiment, the morphological complexity of the Swahili verb paradigm did not influence the agrammatic behavior.

As in our earlier studies (Abuom & Bastiaanse, 2012, 2013), there is a strong and significant correlation between the performance in both languages, meaning that when the agrammatic individuals are poor in one construction in one language, they perform poorly in the other language as well. The same was found in the present study, which is contrary to the assumption that a central underlying deficit in bilingual individuals with agrammatic Broca’s aphasia may cause different surface manifestations in the languages that differ in their grammatical morphology (Fabbro, 2001; Paradis, 1988). Given that these agrammatic speakers were early balanced bilinguals who acquired both languages early in life and were equally proficient in both languages at the time of their aphasia producing incident, we attribute their level of performance in both languages to shared language processing brain regions for derived order sentences (e.g. Abutalebi et al., 2005; Miozzo et al., 2010).

In sum, in our group of bilingual agrammatic individuals, sentence comprehension is significantly hampered by derived word order. Embedding further diminished their performance. The latter finding is not compatible with the TDH, nor with any other representational theory. The DOP-H, that is very similar in its assumption that derived order of the constituents is hard for agrammatic individuals, is a processing theory. This means that the syntactic representations in agrammatic aphasia are intact, but application of the linguistic operations to extract information from word order is impaired when word order is derived. The present study demonstrates that the DOP-H makes correct prediction and also shows that application of another linguistic operation (embedding) further reduces correct interpretation of the complex sentences.

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## Notes

1. For comprehension studies, the term ‘Broca’s aphasia’ is often used. We prefer the term ‘agrammatic aphasia’ here, to show that our participants were not only suffering from Broca’s aphasia but also spoke in telegraphic speech.
2. With the exception of one agrammatic individual (BM), the agrammatic participants participated in a previous study on time reference (see Abuom & Bastiaanse, 2013). Three of the agrammatic individuals (EA, MM and HJ) had also participated in an earlier study on bilingual agrammatic spontaneous speech (see Abuom & Bastiaanse, 2012).
3. Unfortunately, in Kenya there are no tests available to establish the aphasia syndrome. The BDAE cannot be used to classify the aphasia type in Kenya because of cultural bias.

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